DOCUMENT-IDENTIFIER: US 5699440 A
TITLE: Method and system for testing the performance of at least one
electro-optical test device

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DWKU:
5699440

ABPL:
A method and system for testing the performance of at least one electro-optical
test device, comprising constructing an electro-optical system having a light
source, a test target, a lens and an imaging device as required in combination
with the test devices. A respective identity code of a plurality of
precalibrated devices together with corresponding electro-optical performances
are stored in a database and the imaging device is aligned to the test target
so as to produce a focused image thereof. Pre-calibbrated devices are selected
from the database and the focussed image is digitized and stored so as to
produce a digitized image which is analyzed so as to determine an
electro-optical performance representative of the performance of the
electro-optical system which is equal to the product of component
electro-optical performances of each of the electro-optical test devices and
each of the additional pre-calibrated devices. This permits determination of
the product of component electro-optical performances of each of the
electro-optical test devices.

BSPR:
Various prior art systems relate to the setup and calibration of specific
optical components within a pre-calibrated optical

system. For example, U.S. Pat. No. 4,316,211 (Mackey et al.) discloses a convergence measuring apparatus for use with a color television kinescope and deflection yoke comprising means for activating two of the electron beams of the kinescope to generate a convergence test pattern on the kinescope display screen. The convergence test pattern is a set of alternating color patches. The degree of overlap and gap between patches is indicative of the degree of beam misconvergence. A monogram television camera observes the test pattern and provides a signal to a signal processor which controls the electron beam activating means to move one color patch with respect to the other color patch so as to reduce the gap and overlap between patches. A measurement of the amount of patch movement necessary to minimize the overlap and gap between patches is an indication of electron beam misconvergence in the vicinity of the test pattern.

BSPR:
In use, a test chart is imaged by the television camera to which may be coupled different lenses, the characteristics of which are pre-calibbrated and stored in the lens memory. The calibration is effected by means of an external test pattern which is positioned in front of the camera. The difference between the correction information associated with the different lens systems and determined by means of the external test pattern, and the correction information associated with the internal test pattern is stored by the supplier in the respective digital lens memory. As a result, each lens system has its own lens memory with correction information stored therein:

BSPR:
Such a system provides for automatic setup of a television camera with a

plurality of pre-calibrated lens systems. However, no provision is made for altering other components in the optical system such as, for example, the test target or the light source.

BSPR:
Such a system permits visual inspection by an operator and permits a visual comparison to be made between the actual image signal produced by a television camera and a reference test signal. However, the comparison itself is substantially subjective and no absolute calibration of the television camera is thus provided. Furthermore, the electro-optical system is fixed and no provision is made for substituting component devices thereof or for evaluating the performance of different sub-components of the system.

BSPV:
(a) coupling to said at least one electro-optical test device additional pre-calibrated devices as required so as to construct an electro-optical system having a light source, a test target, a lens and an imaging means,

BSPV:
(b) storing a respective identity code of a plurality of pre-calibrated devices together with corresponding electro-optical performances,

BSPV:
(d) specifying which devices, if any, in said electro-optical system are pre-calibrated,

BSPV:
(f) analyzing the digitized image so as to determine an electro-optical performance representative of the performance of the electro-optical system and being equal to the product of component electro-optical performances of each of said at least one electro-optical test device and each of

said additional
pre-calibrated devices, and

BSPV:
an electro-optical system including said at least one electro-optical test
device coupled to additional pre-calibrated devices as required, said
electro-optical system comprising a light source, a target, a lens and an
imaging means,

BSPV:
a computer coupled to the electro-optical system and including a memory for
storing therein a database of pre-calibrated device identity codes and
corresponding electro-optical performances thereof,

BSPV:
an analysis means coupled to the memory for determining an electro-optical
performance representative of the performance of the electro-optical system and
being equal to the product of component electro-optical performances of each of
said at least one electro-optical test device and each of said additional
pre-calibrated devices, said analysis means further for determining the product
of component electro-optical performances of each of said at least one
electro-optical test device.

DEPR:
The electro-optical system 11 is constructed from high performance and
pre-calibrated components in conjunction with the device to be tested. The
electro-optical system 11 includes a video camera 12, a lens 13, a target 14
and a light source 15, one of these being the test device and all the others
being high performance, pre-calibrated components. The electro-optical system
11 is coupled to a digitizer 16 which itself is coupled to a computer 17
including a memory (not shown) for digitizing and storing

the image formed by the electro-optical system 11. The computer 17 includes an analysis unit (not shown) for analyzing the performance of the electro-optical system 11 and, in particular, of the test device therein.

DEPR:
In use, an image is produced by the camera 12 and the image is digitized by the digitizer 16 and stored in the memory of the computer 17. Owing to aberrations associated with the test device, the image is distorted compared with a theoretical ideal image which would be obtained if the test device were replaced by an equivalent high performance device. It is therefore possible to evaluate the performance of the test device relative to an equivalent high performance, pre-calibrated device.

DEPR:
FIG. 1b shows a second embodiment of the invention wherein it is desired to test the performance of a display device 18. To this end, the electro-optical system 11 comprises an electronic signal test generator 19 coupled to the display device 18 which in turn is imaged by a calibrated camera 12 through a calibrated lens 13. The calibrated camera 12 is coupled to the digitizer 16 and the computer 17 as described above with reference to FIG. 1a of the drawings. In such a system, the electronic signal test generator 19 replaces the target 14 and the light source 15 shown in FIG. 1a for producing a video image signal which is displayed by the display device 18 whose screen is imaged by the calibrated camera 12 so as to produce a video image which is evaluated in an identical manner to that described above with reference to FIG. 1a of the drawings.

DEPR:

Consequently, since all the sub-components in the electro-optical system 11 apart from the device or devices under test are pre-calibrated, the performance of the test device or devices may be evaluated based on the linear relations described above.

DEPR:
Reference is now made to FIG. 2a of the drawings showing the principal operating steps in a method according to the invention for evaluating the test performance of the electro-optical system 11 shown in FIGS. 1a and 1b. Within the memory of the computer 17 there is stored a database of pre-calibrated components permitting representative electro-optical performances thereof to be stored and also permitting storage of various physical characteristics of each device, such as physical dimensions, which are necessary for proper alignment of the electro-optical system. The electro-optical system 11 is then constructed by coupling the test device or devices to standard components for which the calibration data is stored in the database. Under control of software stored in the computer 17, the required setup is specified by selecting from the database the corresponding standard, pre-calibrated components whose physical and optical data are thus known. An image is formed and is aligned so as to produce sharp focus and correct for optical magnification so that the target is correctly aligned to the lens and camera.

DEPR:
Thereafter, the resulting image is digitized and analyzed so as to determine the required electro-optical performances of the complete system. Since the calculated electro-optical performance is a product of the corresponding electro-optical performances of each of the component

devices in the
electro-optical system, and since moreover the
corresponding electro-optical
performances of the pre-calibrated components are known,
the resulting
electro-optical performance of the test device or the
product of the
electro-optical performances of the test devices may
easily be determined and
displayed, as required, on a display monitor (not shown)
coupled to the
computer 17.

DEPR:
Owing to the setup procedure, any standard calibrated
electro-optical component
can be substituted for corresponding devices in the
electro-optical system,
re-alignment can be effected and the analysis can be
performed again as
required. Much more significant, however, is the reverse
situation whereby
analysis can be performed with the specific, limited
range of components
typically available to the end user who needs to
correlate the analysis
software within the computer 17 to the range of
components actually in his
possession. With the prior art systems discussed in the
opening section of the
specification this is not possible because the only
degree of freedom is the TV
camera under test.

DEPR:
In addition, for each item, a full and detailed
specification is entered the
stored parameters being different for each different type
of component and
being sufficient to permit the various electro-optical
performances to be
calculated for each component. Finally, any known
calibration data is entered
for the item and, if not known, this information is
merely left blank.

DEPR:
Thus, on the basis of the calibration data in the

database shown in Table I,
the system calculates the coordinates on the CCD with respect to an origin
thereof, typically the top left hand corner. These coordinates must now be
converted to equivalent serial video signals based on the number of the CCD
scan line corresponding to each y location and the scan time, .DELTA.t, to
reach each x location. The conversion is also dependent on the CCD calibration
data stored in the database, according to the following formulae: ##EQU3##
wherein: 242 is the number of active TV lines in the video field of the EIA
standard;

DEPR:
FIG. 11 shows schematically a detail of the reticle 22 having thereon at known
pre-calibrated locations a plurality of input points 45 denoted by crosses.
Superimposed thereon is a like plurality of output points 46 denoted by circles
which are not exactly coincident with the crosses 45 owing to distortion
through the reticle 22. Distortion may be evaluated by normalizing the actual
positions of the output points 46 according to their expected positions.

DEPR:
FIG. 12 shows schematically a detail of the reticle 22 having thereon a color
chart denoted .generally by 47 and comprising a plurality of different colored
regions. Each colored region is formed of a known, pre-calibbrated mix of
primary colors e.g. Red (20%), Green (35%) and Blue (45%). The color mix of
the corresponding region of the display device (constituted by a color monitor)
is evaluated, and any deviation from the pre-calibrated color mix is measured
in order to establish the chromaticity of the color monitor.

DEPR:

FIG. 13a shows a detail of a reticle for determining the transient response of an electro-optical system due to a sudden increase in light flux. The reticle 50 contains a transparent white area 51 for transmitting light therethrough adjacent to a black area 52 which is nominally opaque to light. The black area 52 is used for calibration purposes so as to determine the relative transmittance of the transparent area 51. Light having an intensity L.sub.1 is passed through the transparent area 51 of the reticle 50 at a time t=t.sub.1 -.epsilon. and is illuminated by light having an intensity L.sub.2 at a time t=.sub.1 +.epsilon. where .epsilon. is a short time interval.

DEPV:
Calibration data (if available): MTF, CTF and so on.

DEPV:
Reticle: (calibrated) ID: DEM-RTC

DEPV:
Optics: (calibrated) ID: DEM-OPT

DEPV:
Light source (calibrated) ID: DEM-LHT

DEPW:
Calibration data: Diffraction limit

CLPV:
(c) defining all the other electro-optical devices of the electro-optical system that have not been selected as electro-optical test devices as pro-calibrated devices of the system;

CLPV:
(d) creating a database for storing a respective identity code of a plurality of different types of pro-calibrated devices including said pre-calibrated devices of the system together with corresponding electro-optical performances,

CLPV:
an electro-optical system including said at least one electro-optical test
device coupled to pre-calibrated devices, said electro-optical system
comprising a light source, a target, a lens and an imaging means,

CLPV:
a computer coupled to the electro-optical system and including a memory for
storing therein a database of pre-calibrated device identity codes and
corresponding electro-optical performances thereof in respect of a plurality of
different types of pre-calibrated electro-optical device including said
pre-calibrated devices,

CLPV:
an analysis means coupled to the memory for determining an electro-optical
performance representative of the performance of the electro-optical system and
being equal to the product of component electro-optical performances of each of
said at least one electro-optical test device and each of said pre-calibrated
devices, said analysis means further for extracting from the database the
electro-optical performances of each of the pre-calibrated devices and for
determining the product of component electro-optical performances of each of
said at least one electro-optical test device.

CLPV:
the target includes a high accuracy pre-calibrated reticle for forming an image
by said at least one electro-optical test device, and